Claims:

1. An orthogonal wavelet division multiplexing (OWDM) communication system, comprising:

a synthesis section comprising a filter pair bank with a plurality of inputs and an output, each input receiving a corresponding one of a plurality of symbols of a supersymbol and the output asserting an OWDM signal that represents the supersymbol;

wherein each symbol of the supersymbol comprises a selected one of a predetermined symbol set of a selected modulation scheme and wherein the OWDM signal comprises a linear combination of weighted OWDM pulses, each weighted OWDM pulse being representative of a corresponding symbol of the supersymbol; and

a channel interface, coupled to the output of the synthesis section, that is configured to assert an OWDM signal onto a channel.

2. The OWDM communication system of claim 1, wherein the synthesis section receives and processes a stream of symbols to provide successive OWDM signals over successive blocks of time and wherein successive OWDM signals are superposed to produce an overall OWDM signal.

3. The OWDM communication system of claim 1, wherein the synthesis section comprises at least one filter pair stage from input to output of the synthesis section, wherein each filter pair stage includes at least one pair of filters, wherein each filter of each filter pair has an input coupled to an output of an upsampler, wherein each filter pair includes a pair of outputs coupled to respective inputs of an adder and wherein each successive stage, if any, from input to output, includes half as many filter pairs as an adjacent previous stage.

4. The OWDM communication system of claim 1, wherein the synthesis section comprises an n-stage filter pair bank in which n is a positive even integer, the n-stage filter pair bank comprising:

an input stage, comprising:

an input set of $2^n/2$ wavelet filter pairs, each pair receiving two symbol inputs and a pair of outputs; and

a set of $2^n/2$ adders, each having an output and a pair of inputs coupled to a corresponding pair of outputs of the input set of $2^n/2$ wavelet filter pairs;

at least one intermediate stage, comprising:

a set of x wavelet filter pairs, wherein x is half the number of wavelet filter pairs of a preceding stage, each wavelet filter pair having a pair of outputs and a pair of inputs coupled to two corresponding outputs of a preceding set of adders; and

a set of x adders, each having an output and a pair of inputs coupled to a corresponding pair of outputs of the x wavelet filter pairs of a current intermediate stage; and

a final stage, comprising:

a wavelet filter pair having a pair of outputs and a pair of inputs coupled to two corresponding outputs of a preceding set of adders; and

a final adder having a pair of inputs coupled to the pair of outputs of the final stage wavelet filter pair and an output that provides the OWDM symbol representing the supersymbol.

5. The OWDM communication system of claim 4, wherein each synthesis section wavelet filter is preceded by a set of up samplers.

6. The OWDM communication system of claim 1, further comprising:

a serial to parallel converter that converts a stream of symbols received at an input to sets of supersymbols at an output coupled to an input of the synthesis section.

7. The OWDM communication system of claim 1, further comprising:

a clipper circuit, coupled to the output of the synthesis circuit, that limits a magnitude of the OWDM signal to a predetermined peak value.

8. The OWDM communication system of claim 1, wherein a first input of the synthesis section is zeroed to enable AC coupling.

9. The OWDM communication system of claim 1, wherein the weighted OWDM pulses and the OWDM signal are broad-time pulses.

10. The OWDM communication system of claim 1, wherein the selected modulation scheme is according to a Quadrature Phase Shift Keying scheme.

11. The OWDM communication system of claim 1, wherein the selected modulation scheme is a Quadrature Amplitude Modulation scheme.

12. The OWDM communication system of claim 1, further comprising:

the channel interface being further configured to receive a channel-modified OWDM signal transmitted via the channel;

an adaptive equalizer, coupled to the channel interface, that uses OWDM pulses and an error signal to perform an inverse process of the channel to convert the channel-modified OWDM signal into an estimated OWDM signal;

an analysis section comprising a filter pair bank with an input coupled to the output of the adaptive equalizer for receiving the estimated OWDM signal and an output for asserting a corresponding plurality of decision statistics; and

a detection circuit, having an input coupled to the output of the analysis section, that interprets each of the plurality of decision statistics based on the predetermined symbol set, that asserts a corresponding plurality of estimated symbols at an output, that measures an error of the plurality of decision statistics and that asserts the error signal to the adaptive equalizer.

13. The OWDM communication system of claim 12, wherein the synthesis and analysis sections each comprises a multistage tree-structured quadrature mirror filter bank.

14. The OWDM communication system of claim 12, wherein the synthesis and analysis sections each comprise a tree structure of low pass filter (LPF) and high pass filter (HPF) pairs.

15. The OWDM communication system of claim 14, wherein the LPF and HPF pairs are Jain filters.

16. The OWDM communication system of claim 15, wherein the LPF and HPF pairs of the analysis section are the same as the LPF and sign-negated HPF pairs of the synthesis section.

17. The OWDM communication system of claim 14, wherein the LPF and HPF pairs are Daubechies filters.

18. The OWDM communication system of claim 17, wherein the LPF of each filter pair of the analysis section is the order-reversed LPF of the synthesis section, and the HPF of each filter pair of the analysis section is the order-reversed and alternately sign-negated HPF of the synthesis section.

19. The OWDM communication system of claim 14, wherein the LPF and HPF pairs are based on a single prototype filter.

20. The OWDM communication system of claim 12, wherein the analysis section comprises at least one filter pair stage from input to output of the analysis section, wherein each filter pair stage includes at least one pair of filters, wherein each filter of each filter pair has an output coupled to an input of an upsampler and wherein each successive stage, if any, from input to output, includes twice as many filter pairs as an adjacent previous stage.

21. The OWDM communication system of claim 12, wherein the analysis section comprises an n-stage filter bank in which n is a positive even integer, the n-stage filter bank comprising:

an input stage including a wavelet filter pair having an input receiving the estimated OWDM pulse and a pair of outputs;

an output stage including a set of $2^n/2$ wavelet filter pairs, each wavelet filter pair of the output stage having an input coupled to a corresponding one of a pair of outputs of a corresponding wavelet filter pair of a previous stage and a pair of outputs asserting a corresponding pair of the plurality of decision statistics; and

at least one intermediate stage, each intermediate stage including a set of x wavelet filter pairs wherein x is twice the number of wavelet filter pairs of a preceding stage, wherein each wavelet filter pair has a pair of outputs and an input coupled to a corresponding one of a pair of outputs of a corresponding wavelet filter pair of a previous stage.

22. The OWDM communication system of claim 21, wherein each analysis section wavelet filter is followed by a set of down samplers.

23. The OWDM communication system of claim 12, wherein the channel interface comprises a media access control and physical circuit that is configured to communicate via a wireless medium.

24. The OWDM communication system of claim 12, wherein the adaptive equalizer includes a programmable equalizer that is initially adjusted based on reception of a plurality of predetermined transmitted OWDM signals during a training phase.

25. The OWDM communication system of claim 24, wherein the adaptive equalizer further comprises:

an adaptation block, coupled to the programmable equalizer and the detection block, that initially adjusts the programmable equalizer during the training phase and that updates the programmable equalizer based on the error signal during operation.

26. The OWDM communication system of claim 12, further comprising:

a parallel to serial converter having an input coupled to the output of the detection circuit that converts each estimated supersymbol into a stream of estimated symbols.

27. An orthogonal wavelet division multiplexing (OWDM) spread spectrum (OWSS) communication system, comprising:

a transmitter, comprising:

a first series of multipliers, each having a first input that receives a selected symbol of a predetermined symbol set of a selected modulation scheme, a second input that receives a corresponding code of a selected one of a first plurality of orthogonal code vectors and an output;

a second series of multipliers, each having a first input coupled to an output of a corresponding one of the first series of multipliers, a second input that receives a corresponding OWDM pulse of a first family of doubly orthonormal OWDM pulses and an output; and

a first adder having a plurality of inputs and an output, each input coupled to an output of the second series of multipliers and the output providing an OWSS signal; and

a channel interface, coupled to the output of the first adder, that is configured to assert the OWSS signal onto a channel.

28. The OWSS transceiver of claim 27, wherein the first family of doubly orthonormal OWDM pulses comprises broad-time pulses and wherein each code of the first plurality of orthogonal code vectors spread OWDM pulses so that the OWSS signal is a broad-time and broadband signal.

29. The OWSS communication system of claim 28, wherein the selected modulation scheme is a Quadrature Amplitude Modulation (QAM) scheme.

30. The OWSS communication system of claim 29, wherein the selected modulation scheme is QAM-64.

31. The OWSS communication system of claim 27, further comprising:

a memory, coupled to the transmitter, that stores the first plurality of orthogonal code vectors and a digital representation of the first family of doubly orthonormal OWDM pulses.

32. The OWSS communication system of claim 27, wherein the channel interface comprises a media access control and physical device.

33. The OWSS communication system of claim 27, further comprising:

the channel interface being further configured to receive a channel-modified OWSS signal transmitted via the channel;

an adaptive equalizer, coupled to the channel interface, that uses an error signal to perform an inverse process of the channel to convert the channel-modified OWSS signal into an estimated OWSS signal;

a correlator bank and adder, comprising:

a third series of multipliers, each having a first input coupled to the output of the adaptive equalizer to receive the estimated OWSS signal, a second input that receives a corresponding OWDM pulse of a second family of doubly orthonormal OWDM pulses and an output, the second family of doubly orthonormal OWDM pulses comprising complex conjugates of the first family of doubly orthonormal OWDM pulses;

a fourth series of multipliers, each having a first input coupled to an output of a corresponding one of the third series of multipliers, a second input that receives a

corresponding code of a selected one of a second plurality of orthogonal code vectors and an output; and

a second adder having a plurality of inputs and an output, each input coupled to an output of the fourth series of multipliers and the output providing a decision statistic; and

a detect and decision feedback (DFB) error block, having an input coupled to the output of the second adder and an output, that interprets the decision statistic based on the predetermined symbol set, that asserts an estimated symbol at the output, that measures an error of the estimated symbol and that asserts the error signal to the adaptive equalizer.

34. The OWSS communication system of claim 33, wherein each OWDM pulse of the first and second families of doubly orthonormal OWDM pulses are generated by a tree-structured wavelet filter pair bank.

35. The OWSS communication system of claim 34, wherein the tree-structured wavelet filter pair bank comprises a multistage filter bank of wavelet filter pairs.

36. The OWSS communication system of claim 33, wherein the first and second families of doubly orthonormal OWDM pulses comprises broad-time pulses.

37. The OWSS communication system of claim 33, wherein the second plurality of orthogonal code vectors is a modified version of the first plurality of orthogonal code vectors to improve performance.

38. The OWSS communication system of claim 33, wherein each code vector of the first and second plurality of orthogonal code vectors corresponds to one of a plurality of users.

39. The OWSS communication system of claim 33, wherein the first and second plurality of orthogonal code vectors are based on Walsh-Hadamard codes.

40. The OWSS communication system of claim 33, further comprising:

a memory, coupled to the correlator bank and adder, that stores the first and second plurality of orthogonal code vectors and digital representations of the first and second family of doubly orthonormal OWDM pulses.

41. The OWSS communication system of claim 33, further comprising:

the first and second plurality of orthogonal code vectors being the same; and

a memory, coupled to the transmitter and the correlator bank and adder, that stores the plurality of orthogonal code vectors and a digital representation of the first and second families of doubly orthonormal OWDM pulses.

42. The OWSS communication system of claim 33, wherein the channel interface comprises a media access control and physical circuit that is configured to communicate via a wireless medium.

43. The OWDM communication system of claim 33, wherein the adaptive equalizer includes a programmable equalizer that is initially adjusted based on reception of at least one predetermined transmitted OWSS signals during a training phase.

44. The OWSS communication system of claim 43, wherein the adaptive equalizer further comprises:

an adaptation block, coupled to the programmable equalizer and the detect and DFB error block, that initially adjusts the programmable equalizer during the training phase and that uses the error signal that is provided by the detect and DFB error block for equalizer adaptation during operation.

45. The OWSS communication system of claim 33, wherein the adaptive equalizer further comprises:

a Forward Equalizer (FE);

a Decision Feedback Equalizer (DFE) coupled to the detect and DFB error block and the FE;

an adder coupled to the FE, the DFE and the correlator bank and adder; and

an adaptation block, coupled to the detect and DFB error block, the FE and the DFE, that adjusts the FE and DFE during an initial training phase and that adjusts the FE and DFE using the error signal from the detect and DFB error block during operation.

46. An orthogonal wavelet division multiplexing (OWDM) spread spectrum (OWSS) communication system, comprising:

a first memory that stores a first set of OWSS pulses comprising a plurality of OWSS pulse vectors, each OWSS pulse vector comprising a combination of a selected code vector of a first set of orthogonal code vectors and a first family of doubly orthonormal OWDM pulses;

a transmitter, coupled to the first memory, that combines a symbol of a predetermined symbol set of a selected modulation scheme with a selected OWSS pulse vector from the first memory into an OWSS signal; and

a channel interface, coupled to the transmitter, that is configured to assert the OWSS signal onto a channel.

47. The OWSS communication system of claim 46, wherein the channel interface comprises a media access control and physical circuit that is configured for wireless communications.

48. The OWSS communication system of claim 46, wherein the selected modulation scheme is Quadrature Amplitude Modulation (QAM).

49. The OWSS communication system of claim 46, wherein the selected modulation scheme is QAM-64.

50. The OWSS communication system of claim 46, wherein the transmitter includes a set of multipliers and an adder.

51. The OWSS communication system of claim 46, further comprising:

the channel interface further being configured to receive a channel-modified OWSS signal transmitted via the channel;

a second memory that stores a second set of OWSS pulses comprising a plurality of OWSS pulse vectors, each OWSS pulse vector comprising a combination of a selected code vector of a second set of orthogonal code vectors and a second family of doubly orthonormal OWDM pulses;

an adaptive equalizer, comprising:

a forward equalizer (FE), coupled to the channel interface, that converts the channel-modified OWSS signal into an equalized signal;

an adder, coupled to the forward equalizer, that subtracts a feedback signal from the equalized signal and asserts an estimated OWSS signal;

a decision feedback equalizer (DFE), coupled to the adder, that receives estimated symbols and that provides the feedback signal to the adder; and

an adaptation block, coupled to the FE and the DFE, that uses an error signal to update the FE and DFE;

a correlator, coupled to the second memory and the adaptive equalizer, that combines the estimated OWSS signal with a selected OWSS pulse vector from the second memory and that asserts a decision statistic at its output; and

a detector and decision feedback (DFB) error block, coupled to the correlator, that interprets the decision statistic based on the predetermined symbol set, that provides the estimated symbol, that measures an error of the estimated symbol and that asserts the error signal.

52. The OWSS communication system of claim 51, further comprising:

a delay device inserted between the adder and correlator.

53. The OWSS communication system of claim 51, wherein the first and second orthogonal code vectors are the same, the first and second families of doubly orthonormal OWDM pulses are the same and the first and second sets of OWSS pulse vectors are the same.

54. The OWSS communication system of claim 53, wherein the first and second memories comprise a single memory.

55. The OWSS communication system of claim 51, wherein the correlator comprises a plurality of multipliers that generate a plurality of partial decision statistics and an adder that sums the plurality of partial decision statistics into the asserted decision statistic.

56. The OWSS communication system of claim 51, wherein the FE and DFE are initially adjusted by the adaptation block based on reception of a plurality of predetermined OWSS symbols during a training phase.

57. The OWSS communication system of claim 56, wherein the adaptation block further adjusts the FE and DFE during operation.

58. The OWSS communication system of claim 51, wherein each code vector of the first and second sets of orthogonal code vectors corresponds to one user of a plurality of users.